US006634976B1

(12) United States Patent
Britt

(10) Patent No.: US 6,634,976 B1
(45) Date of Patent: Oct. 21, 2003

(54) **SPEED VARIATOR TRANSMISSION**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/866,993**

(22) Filed: **May 29, 2001**

(51) **Int. Cl.**[7] **F16H 3/72**

(52) **U.S. Cl.** **475/91**; 475/89; 475/93; 475/198; 475/204

(58) **Field of Search** 475/91, 89, 93, 475/106, 198, 204, 290

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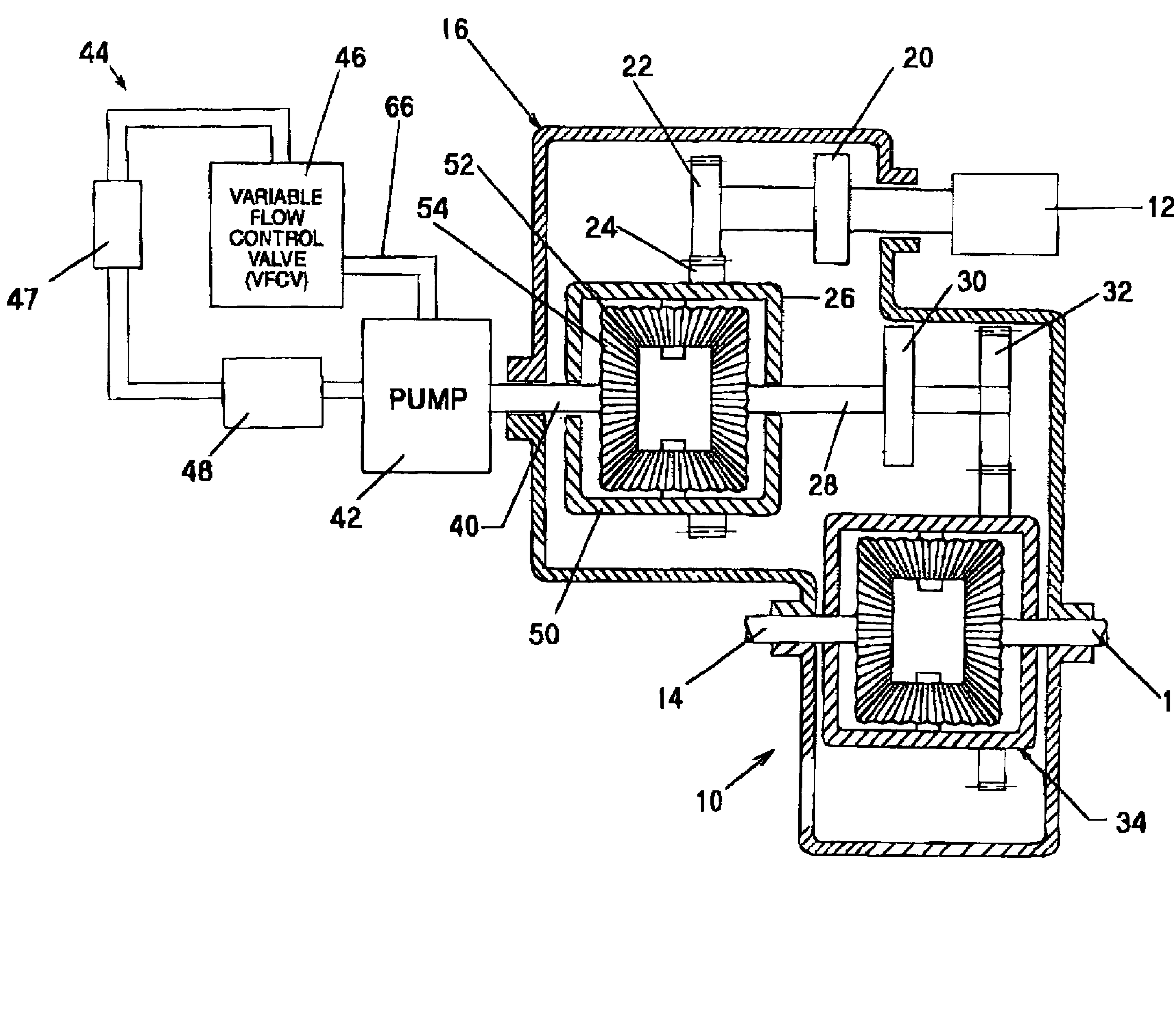
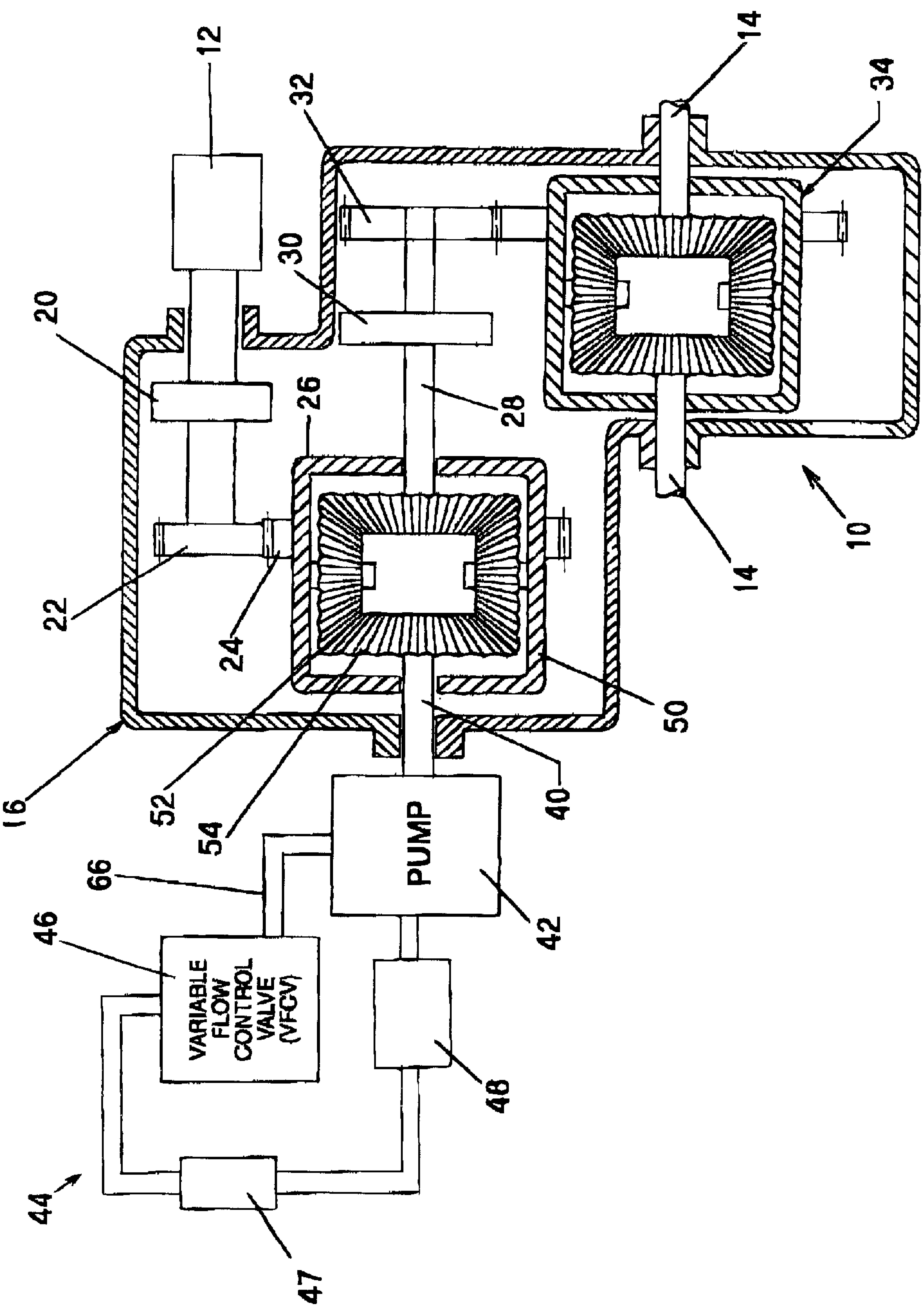
(57) **ABSTRACT**

A continuously variable ratio transmission includes a planetary gear set connected to a prime mover having first and second output shafts. The first output shaft is connected in a hydraulic braking circuit including a positive displacement pump and an operator controlled variable flow valve for varying the resistive torque on the output shaft and effective a gear ratio change at the other output shaft.

8 Claims, 2 Drawing Sheets

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VARIABLE FLOW CONTROL VALVE (VFCV)
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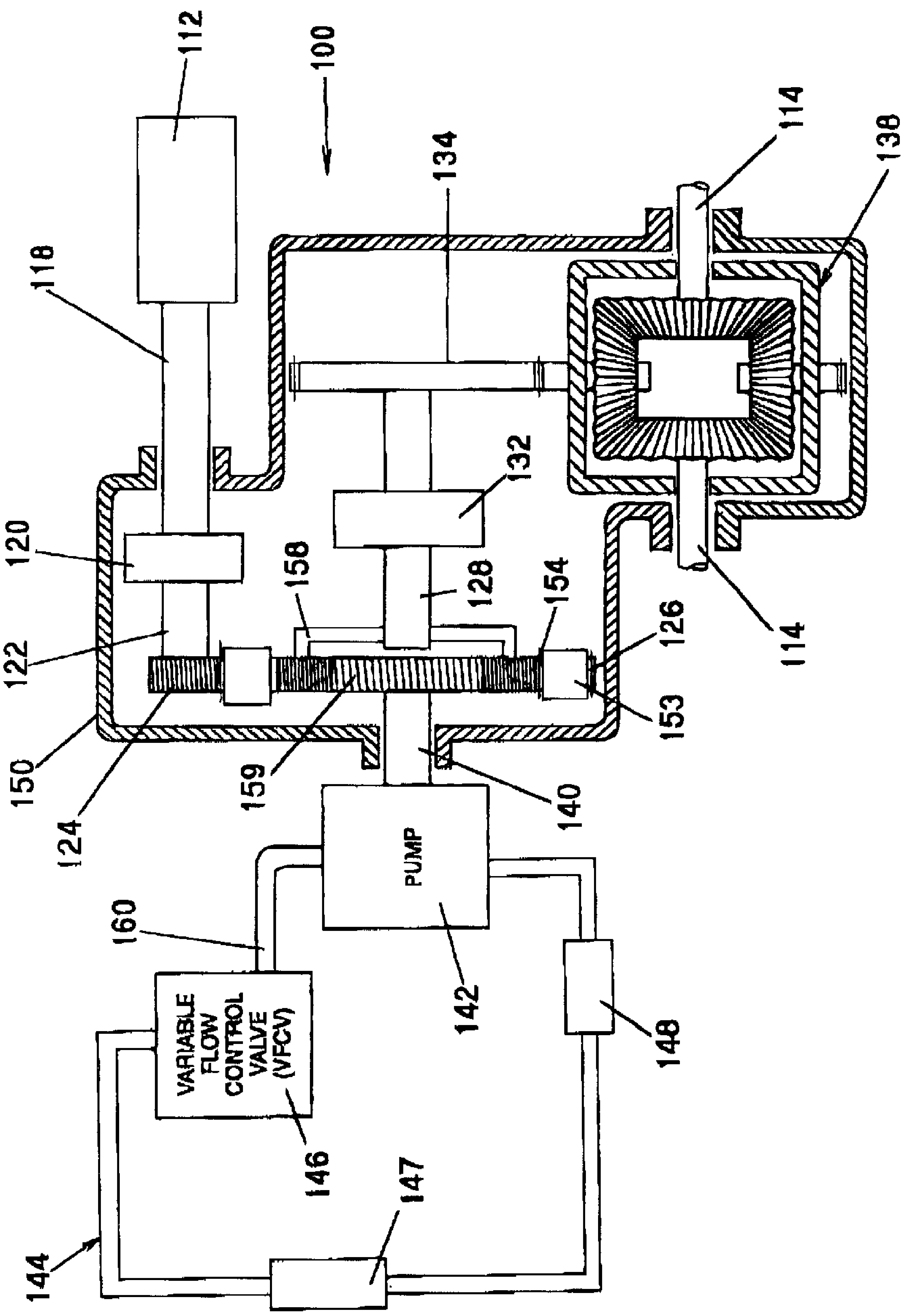
FIG. 1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VARIABLE FLOW CONTROL VALVE (VFCV)
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144

FIG. 2

SPEED VARIATOR TRANSMISSION

FIELD OF THE INVENTION

The present invention relates to power transmission, and, in particular, a speed variator for providing continuously variable ratio on the transmission of power.

BACKGROUND OF THE INVENTION

Many approaches have been taken in the prior art to provide for transmission of power between a prime mover, such as an engine or motor, and a device driven thereby. In the vehicular field, transmissions are available providing a variety of gear ratios, manually or automatically. However, there has been continuing interest in power transmitting to provide stepless, continuously variable speed transmission wherein the relative speed between an input shaft and an output shaft can be continuously varied.

A favored approach has been to utilize a variator system in which the speed of an output shaft is dependent on the relative speeds of the input shaft and an auxiliary variator shaft. Utilizing primarily variable pitch pulleys, planetary gearing and differential gearing, varying components have been used to allow an operator to achieve an output ratio in accordance with operator preference or equipment performance demands.

In U.S. Pat. No. 5,167,591 to Cowan, an infinitely adjustable, variable speed transmission for bicycles is disclosed wherein a variator including manually adjustable variable pitch pulleys are used to vary the output speed of planetary gearing connected to the driven bicycle wheel. A related system is disclosed in U.S. Pat. No. 5,167,591 to Cowan. A further such system is disclosed in U.S. Pat. No. 4,553,450 to Gizard. The speed ratio range afforded the pulley system is limited.

Other approaches have used toroidal race drives such as disclosed in U.S. Pat. Nos. 5,667,458 to Fellows and 4,628,766 to Perry. Such transmissions are mechanically complex and costly. Electromechanical braking of one shaft of a twin differential gear set is disclosed in U.S. Pat. No. 2,441,606 to Trofimov to provide limited variation in gear ratio between a prime mover and an output drive train.

In view of the foregoing, it would be desirable to provide a compact variator for infinitely adjusting the output speed in a drive train in a manner that overcomes the foregoing limitations heretofore associated with variable pitch pulleys and friction drives, and like variators.

Accordingly, it is an object of the present invention to provide a variator providing affirmative, continuously adjustable differential output speeds.

Another object of the invention is to provide a variable ratio transmission using a hydraulic brake to continuously vary output speed between ratio limits.

A further object of the invention is to provide a speed variator for a drive transmission using a variable flow, positive displacement hydraulic circuit to vary the output speed of a planetary drive train.

SUMMARY OF THE INVENTION

The foregoing objects are accomplished by a variable speed transition wherein a secondary differential disposed between the prime mover input shaft and differential driven output shafts has one output shaft coupled with a variable flow control valve and positive displacement pump in a

hydraulic circuit for providing variable braking thereto effecting a ratio change in the other output shaft thereby selectively changing the drive train ratio. The secondary differential may employ planetary gearing or conventional differential bevel gearing. At open condition, the controlled output shaft is minimally braked and a direct drive is provided to the output differential. As the valve is closed, the output pressure increase at the positive displacement pump and effects an increasing resistive torque at the shaft resulting in an increased speed at the output shaft. At full control valve closure, the differential is locked and a final drive ratio approaching the theoretic ratio of 2:1 is established, with continuous variable control therebetween. For incorporation in to vehicles, from passenger and recreational to commercial, appropriate clutching and reverse gearing may be incorporated.

DESCRIPTION OF THE DRAWINGS

The above and other objects and advantages of the present invention will become apparent upon reading the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. **1** is an illustrative schematic view of a drive train transmission provided with a variator in accordance with the invention coupled with a differential gear train; and

FIG. **2** is an illustrative schematic view of a drive train transmission and variator coupled with a planetary gear train.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings for the purpose of describing the preferred embodiment and not for limiting same, FIG. **1** illustrates a drive train transmission **10** for delivering at infinitely varying output speed power from a prime mover **12** to shaft outputs **14**, such as the drive wheels of a vehicle or like power consuming load, as accommodated by a variator **16** in accordance with the invention. The prime mover **12** is connected in a driveline with a clutch **20** and an input gear **22** connected with an outer ring gear **24** on the variator carrier. The variator **16** includes a first beveled sun gear connected to drive output shaft **28** in an output driveline including reversal unit **30** and to an input gear **32** to the ring gear of an output differential unit **34** including the output shafts **14**. The variator **16** further includes a variator output shaft **40** connected with the other beveled side sun gear and operatively connected to the impeller of a fluid pump **42** in a closed hydraulic braking circuit **44** including a variable flow control valve **46**, a fluid cooler **47** and a fluid reservoir **48**.

The variator **16** includes the carrier **50** carrying a differential gear set **52**. One side sun gear of the differential get set **52** is connected with the output shaft **40**, and the other side sun gear is connected with the drive output shaft **28**.

The clutch **20** serves to disengage the output shaft **22** of the prime mover **12** from the input shaft of the variator **16** in order to allow the prime mover to idle without operative connection to the transmission. Mechanical, electromechanical, electrochemical, hydraulic clutches and the like may be used for the disengagement function. A hydraulically actuated clutch is preferred.

The fluid pump may be any suitable positive displacement pump effective upon rotational input to receive fluid from the sump and to deliver fluid at an elevated pressure through outlet line **66**. Fixed displacement unidirectional fluid pumps are preferred, such as a gear pump. Such pumps upon rotation of the input shaft are effective for delivering a fluid volume under pressure. When the outlet line is blocked in the presence of input torque, the input shaft is effectively locked. When non-restricted flow is established, the input shaft rotates freely, substantially without resistance above threshold amounts. For flow variations therebetween, progressively closing the control valve **46** increases the braking torque at the variator shaft **40** thereby decreasing the rotational speed thereof and increasing the speed of the output shaft **28** for a given prime mover speed. Accordingly, it will be appreciated that progressive closing of the control valve **46** will effectively increase the output gear ratio of the variator from 1:1 up to the theoretical ratio of 2:1 at lockup of the variator shaft **40** and pump **42**.

The reversing gear set **30** may be any conventional mechanical device effective upon operator command to change the relative rotation of the output shaft **28** and the input to the differential unit **34** thereby reversing the rotation of the output shafts **14**. A planetary unit or a manual gearbox with forward and reverse gears will effect such results in a well known manner.

In operation, by way of illustrative example, with the clutch **20** disengaged and the reversing gear set **30** in forward drive condition, the prime mover **12** freely idles. Upon engagement of the clutch **20**, the input shaft is drivingly engaged with the variator differential **26**. At rest, the flow control valve **46** is fully open and the shaft **40** to the pump **42** rotates against minimal braking torque, and a driving torque is not transmitted. As the flow control valve **46** is progressively closed, the braking torque is effective for progressively increasing the speed of the output shaft **28** from the variator and resultantly the output speed of the shafts **14**. In the fully closed position, maximum braking and accordingly the highest variator gear ratio is provided. Thus in combination with engine speed, the desired gear ratio can be established in accordance with performance and economy preferences.

Referring to FIG. **2**, there is shown a variator transmission **100** using a planetary gear unit for effecting drive ratios at the variator. Therein, the transmission **100** delivers infinitely varying output speed power from a prime mover **112** to output shafts **114**, such as the drive wheels of a vehicle or like power consuming load, as accommodated by a variator **116** in accordance with the invention. The prime mover **112** includes an input shaft **118** connected in a driveline with a clutch **120** and the input shaft **122** and input pinion **124** to the outer ring gear **126** of the variator **16**. The variator **116** further includes an output shaft **128** connected in an output driveline to a reversal unit **132** and to an input pinion **134** drivingly engaging the ring gear **136** of a differential unit **138** driving the output shafts **114**.

The variator **116** further includes a variator shaft **140** operatively connected to a fluid pump **142** having a closed fluid loop **144** including a variable flow control valve **146**, a fluid cooler **147** and a fluid reservoir **148**.

The variator **16** includes a housing **150** carrying a planetary gear differential gear set **152**. The differential get set **152** includes outer ring gear **136** on outer ring **153**, inner ring gear **154** on the ring **153** meshing with planet gears **154** connected to carrier **156** coupled with shaft **128**. The planet gears mesh with sun gear **158** coupled with variator shaft **140**.

The clutch **120** serves to disengage the shaft **122** from the prime mover **112** and the input shaft of the variator **116** in order to allow the prime mover to idle without operative connection to the transmission. Mechanical, electromechanical, electrochemical, hydraulic clutches and the like may be used for the disengagement function. A hydraulically actuated clutch is preferred.

The fluid pump **142** may be any suitable positive displacement pump effective upon rotational input to receive fluid from the reservoir **148** and to deliver fluid at an elevated pressure through outlet line **160**. Fixed displacement unidirectional fluid pumps are preferred, such as a gear pump. Such pumps upon rotation of the input shaft are effective for delivering a fluid volume under pressure. When the outlet line is blocked in the presence of input torque, the input shaft is effectively locked. When non-restricted flow is established, the input shaft rotates freely, substantially without resistance above threshold amounts. For flow variations therebetween, progressively closing the control valve increases the braking torque at the input shaft thereby decreasing the rotational speed thereof and increasing the speed of the output shaft for a given prime mover speed. Accordingly, it will be appreciated that progressive closing of the control valve **146** will effectively increase the output gear ratio of the variator up to the theoretical ratio of 2:1 at lockup of the input shaft to the pump.

The reversing gear set **132** may be any conventional mechanical device effective upon operator command to change the relative rotation of the output shaft **128** and the input to the differential unit thereby reversing the rotation of the rear axle shafts to the wheels. A planetary unit or a manual gearbox with forward and reverse gears will effect such results in a well known manner.

In operation, by way of illustrative example, with the clutch **120** disengaged and the reversing gear **132** in forward drive condition, the prime mover **112** freely idles. Upon engagement of the clutch **120**, the input shaft is drivingly engaged with the variator differential **116**. At rest, the flow control valve **146** is fully open and the variator shaft **140** to the pump **142** rotates against minimal braking torque and a driving torque is not transmitted. As the flow control valve **146** is progressively closed, the braking torque is effective for progressively increasing the speed of the output shaft **128** of the variator and output speed of the drive shafts **114**. In the fully closed position, maximum braking and accordingly the highest variator gear ratio is provided. Thus in combination with engine speed, the desired gear ratio can be established in accordance with performance and economy preferences.

Having thus described a presently preferred embodiment of the present invention, it will now be appreciated that the objects of the invention have been fully achieved, and it will be understood by those skilled in the art that many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the sprit and scope of the present invention. The disclosures and description herein are intended to be illustrative and are not in any sense limiting of the invention, which is defined solely in accordance with the following claims.

What is claimed:

1. In combination: a prime mover having a transverse driveline including an output gear, a pair of transverse output drive shafts coupled to a power consuming load and parallel to said driveline from said prime mover; a planetary gear unit, said planetary gear unit including a carrier having a first set of opposed beveled gears rotatably carried on said carrier and meshing with a second set of opposed beveled gears, said second set being connected with transversely oppositely outwardly extending first and second output shafts; a ring gear on said carrier meshing with said output gear of said drive line of said prime mover; a positive displacement pump connected to said first output shaft of said planetary gear unit; said pump having an input port and an output port; a hydraulic line fluidly connecting said input port and said output port and including an operator controlled variable flow control valve operable between a variable open position and a closed position, said control valve in said open position operable to vary the fluid flow through said hydraulic line and hydraulic pressure at said outlet port thereby varying the torque at said first output and effecting a gear ratio variation at said second output shaft of said planetary gear units; and output drive means operatively connecting said second output shaft to said transverse output drive shafts.

2. The transmission as recited in claim **1** wherein said output drive means is a differential gear unit including a pair of output shafts and an input from said second output shaft.

3. The transmission as recited in claim **1** wherein said positive displacement pump is a gear pump.

4. The transmission as recited in claim **1** wherein said hydraulic line includes a fluid reservoir between said flow control valve and said inlet port.

5. The transmission as recited in claim **4** wherein said hydraulic line includes a fluid cooler between said flow control valve and said inlet port.

6. The transmission as recited in claim **5** including clutch means between said driveline and said planetary gear unit.

7. The transmission as recited in claim **6** wherein said drive means includes gear means for selective changing the rotation said output shafts.

8. The transmission as recited in claim **4** wherein said drive means includes differential gear means connected between said second output and said output shaft.

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